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WHITE
PAPER

***MODIFIED T-37 INSTEAD OF T-46:
IMPACT ON
UNDERGRADUATE PILOT TRAINING***

TACTICAL SUPPORT DIVISION

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<p>This paper examines the repercussions on Undergraduate Pilot Training of using a fully modified T-37 instead of the T-46 as Air Training Command's next generation trainer. The performance deficiencies of the modified T-37 as compared to the T-46 are based on both aircraft attempting to fulfill the requirements outlined in the systems operational concept for the next generation trainer.</p>					
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EXECUTIVE SUMMARY

With the possible termination of the T-46 program, the Air Force has considered using an extensively modified T-37 (T-37M) aircraft instead of the T-46 as the next generation trainer (NGT). Modifications to the current T-37 trainer would include major structural improvements, pressurization, improved ejection seats, new avionics/instrumentation, and a new engine.

When projected performance capabilities of the T-37M are compared to the demonstrated capabilities of the T-46, there are obvious performance deficiencies with the T-37M. Even though the T-37M performance would substantially exceed that of the current T-37B trainer, the T-37M still would not meet T-46 performance standards in eight areas. An assessment of the impact on undergraduate pilot training (UPT) of these deficiencies is included in the table below. The most detrimental effects of using a T-37M instead of the T-46 in UPT would involve reduced climb rates (dual and single engine) and crosswind limitations; nevertheless, these deficiencies would not have a serious impact on the UPT training environment.

T-37M IMPACT ON UPT

<u>Deficiencies</u>	<u>Low</u>	<u>Medium</u>	<u>High</u>	<u>Remarks</u>
Rate of Climb		X		Slower rate reduces training per sortie
Load Factor	X			
Crosswind Limit		X		Training days lost due to crosswinds increases from less than 1% to 3%
Landing Dist	X			
Ejection	X			
Single Engine Takeoff		X		Climb rate 3/4 of NGT requirement
Single Engine Go-Around		X		Gear or flap configuration change required during go-around
Windscreen Capability	X			

Overall, the T-37M could replace the T-46 as the next generation trainer with only minor performance degradations. However, at a pilot production rate of 1800 per year, use of the T-37M with its lower utilization rate as compared to the T-46 could necessitate shifting non-UPT T-37 assets back to UPT. The number of additional aircraft required for UPT would depend on the amount T-37 utilization rates could be increased above the current T-37B level; but even more importantly, the insufficiency would depend on the amount pilot production rates vary from the 1800 per year level.

WHITE PAPER

MODIFIED T-37 INSTEAD OF T-46: IMPACT ON UNDERGRADUATE PILOT TRAINING

PROBLEM

Air Training Command (ATC) has identified both operational deficiencies and a projected airframe insufficiency with the T-37B aircraft, the current primary trainer. ATC has also established requirements for the next generation trainer to handle these shortcomings in a Systems Operational Concept (SOC) and a Mission Element Need Statement (MENS). If the Air Force does not procure the T-46A as its new primary trainer, modified T-37s could replace the current T-37B fleet. A modified T-37 (T-37M) would address many T-37B operational deficiencies, but the recommended modifications would not meet all ATC requirements. At issue then is the impact of using modified T-37s in undergraduate pilot training (UPT) instead of the T-46. This paper discusses T-37M operational deficiencies and subsequent impacts on UPT, and in the second part addresses an interrelated problem, the T-37 airframe insufficiency issue.

FACTORS BEARING ON THE OPERATIONAL DEFICIENCY PROBLEM

1. Facts

a. The T-37 modification packages under consideration include a structural improvement package adding 15,000 hours to the service life, installation of a new engine, and operational improvements such as cockpit pressurization, new avionics and instrumentation, upgraded ejection seats, an improved environmental control system, and an upgraded oxygen system. The upgraded version considered in this paper would incorporate all of the above modifications.

b. Projected investment cost for the 645 T-37M aircraft is \$2.0-2.1 billion (TY\$), or \$3.2M per aircraft, compared to \$3.6 billion (TY\$) for 650 T-46 aircraft, or \$5.5M per aircraft.

c. In assessing life cycle costs, a March 86 Congressional Budget Office (CBO) report projected 20-year life cycle costs of 6.1 billion (86\$) for the T-46 and either 5.1 or 6.2 billion (86\$) for the T-37M. The \$5.1B (T-37M) and \$6.1B (T-46) calculations were based on both aircraft achieving a 60 hours per month utilization rate (UR), while the \$6.2B figure for the T-37M is based on 45 hours per month. The higher life cycle cost for the T-37M is based on CBO's assumption that an additional 100 aircraft must be procured due to the lower utilization rate.

ATC expects a 60 hours per month UR for the T-46, but anticipates that the T-37M, even though extensively modified, could not surpass the current T-37B level of 45 hours per month. Because CBO could not make its own assessment of potential utilization rates, their T-37M life cycle cost calculations were based on two extremes: the projected 60 hours capability of the T-46 and the limited 45 hours capability of the T-37B. The CBO report noted this deficiency and pointed out two previous studies in which ATC used a 50 hours per month rate for the unmodified T-37, and the Analytic Services Corporation

calculated a 56 hours rate for the T-37M. Most likely, the actual T-37M UR would fall between the two extremes.

2. Assumptions

a. According to the San Antonio Air Logistics Center, the avionics and instrumentation packages proposed for the T-37M, as well as the pressurization, oxygen, and environmental control systems, are similar to those used on the T-46A; consequently, these systems would meet ATC requirements.

b. Computer-generated T-37M performance figures, obtained from the Aeronautical Systems Division at Wright-Patterson AFB, accurately estimate that aircraft's performance capabilities.

3. Definitions

a. Next Generation Trainer (NGT) - Replacement aircraft for the T-37B primary trainer.

b. Original NGT specifications - Performance requirements as submitted by ATC in the SOC and MENS; 5000 ft pressure altitude (PA), 100 degrees F (unless stated otherwise).

c. Revised NGT specifications - Less stringent conditions adopted by ATC during flight testing of the T-46; 3800 ft PA, 95 deg F, and other relaxed conditions noted in Criteria section.

d. Critical Field Length - Measurement of single engine capability during takeoff.

e. CAT III operations - Critical field length exceeds runway length; aircrew may not be able to do a takeoff single engine or stop aircraft on available runway.

4. Criteria

a. Justification for new primary trainers is based partially on T-37B performance deficiencies. The modified T-37 addresses the revised standards set by ATC for the NGT but does not meet T-46 specifications in eight areas. In this paper, T-37M capabilities in the eight deficient areas are compared to the operational shortcomings of the T-37B and the demonstrated capabilities of the T-46. These comparisons are then used to determine the impact of using the T-37M instead of the T-46 in the UPT environment.

b. Comparison Figures

Unless noted otherwise, the numbers below indicate the performance capability of each aircraft at the original NGT specifications. The T-37M would not meet specifications in the following eight areas:

	<u>NGT</u>	<u>T-37B</u>	<u>T-46A</u>	<u>T-37M (1)</u>
Rate of Climb (fpm) @25,000ft, Std day TOGW - TO/Climb fuel	2000	860	1850	1206
Sustained Load Factor (g) @25,000ft, Std day	2.5(3)	1.7	2.3 (3)	2.2 (3)
Crosswind Capability (kt)	25	17.5(6)	25	17.5(6)
Landing Distance (ft) 10kt tailwind, RCR 12	5000(2)	6600	5110 4885(2)	5500 5180(2)
Ejection Capability (ft-KIAS)	0-0	100-120	0-0	0-80
Single Engine Takeoff Climb Gradient (deg) 1/2 Flaps, Gear Down	2(2,4)	<0	1.4 2.1(2,4)	0.70 1.6(2,4)
Single Engine Go-Around Climb Gradient (deg) Full Flaps, Gear Down	1(2)	<0	0.97 1.1(2)	0.0(2) 0.7(2,5) 1.0(2,4)
Windscreen Capability (lb-knots)	4-300	4-250	4-300	4-250

NOTES

- (1) T-37M numbers are computer generated estimates from ASD/XPHI
- (2) Based on revised specifications (3800 ft PA, 95 deg F)
- (3) Midpoint instead of beginning of mission (revised criteria)
- (4) Gear retraction allowed in revised criteria
- (5) Requires changing configuration from full to half flaps
- (6) Solo student sorties not allowed above 13 knots

DISCUSSION - OPERATIONAL DEFICIENCIES

Rationale for each NGT requirement and the effect of T-37M shortcomings on UPT are assessed using a low, medium, and high rating scale. The rating indicates to what extent the T-37M would diminish training effectiveness in the UPT environment as compared to the T-46.

1. Rate of Climb - Medium Impact

ATC requires the NGT to have a climb rate fast enough to minimize time and fuel wasted climbing to the training area without hampering the student's ability to achieve proficiency in the climb maneuver early in the program. Due to anticipated growth in civil aviation at lower altitudes, ATC is planning to raise primary training area operations into the 20,000-30,000 ft range.

With a climb rate two thirds that of the T-46, the T-37M would require an additional 3 minutes climbing from 5000 ft to 25,000 ft and approximately 3 minutes extra during a contact profile recovering altitude lost while maneuvering. The profiles considered in the analysis included spins, spin prevents, and aerobatic maneuvers flown with the normal frequency outlined in the UPT syllabus. The extra time spent climbing with the T-37M would mean accomplishing up to 2 fewer aerobatic maneuvers or traffic patterns per contact sortie using the T-37M as compared to the T-46.

2. Sustained Load Factor - Low Impact

According to the SOC, training maneuvers flown in UPT will require performing sustained, level flight, 60 degree bank turns at 25,000 ft MSL. This corresponds to a sustained 2.0 g turn. ATC originally desired a 2.5 g capability calculated at takeoff (T/O) gross weight minus T/O and climb fuel weight; however, ATC later revised the weight criteria with sustained g measurements made midpoint in the training profile. The additional 1/2 g requested for the NGT would accommodate imperfect student technique, allowing up to 66 degrees of bank while maintaining a level turn.

Under this revised weight criteria, the T-46 has only demonstrated a 2.3 sustained g capability at 25,000 ft. ASD projects a 2.2 g capability for the T-37M under the revised (midpoint of mission) specifications. The T-37M would be capable of sustained 60 degree bank maneuvering at 25,000 ft, but would allow for slightly less imperfection in student technique without the loss of altitude when compared to the T-46.

3. Crosswind Capability - Medium Impact

The T-37B has a limited takeoff and landing crosswind capability of 17.5 kts with alterations of normal procedures required above 13 kts. These limitations cause sortie cancellations, affecting not only training continuity but also utilization rates and consequently, the training capacity of UPT wings. By increasing the crosswind capability to 25 kts, ATC could reduce weather losses, exemplified by the following historical weather data.

Table 1. Percent of Training Days Crosswind Exceeds Specified Limits
(Revised Uniform Summary of Surface Weather Observations)

UPT Wing	% of Total UPT Flying Hours	% of Training Days with Crosswinds Exceeding:		
		13kts	17.5kts	25kts
Columbus	19.3	4.0	1.1	0.2
Laughlin	20.2	3.0	1.2	0.2
Reese	18.3	24.0	11.2	2.5
Vance	20.8	10.0	2.7	0.4
Williams	21.4	5.0	1.8	0.2

Considering the average number of hours flown per year at each of the UPT wings, the average number of sorties flown per training day, the percentage of solo student sorties in the T-37 syllabus, and using historical crosswind data, a 25 kt crosswind capability would reduce weather related cancellations from 3% of the training days to less than 1%. Use of the T-37M with its limited crosswind capability would mean losing up to 7 additional days per year due to exceeding crosswind limits. Since utilization rates are directly related to weather cancellations, increasing crosswind capability to 25 kts would also raise utilization rates approximately 1.0 hour per month. The T-37M does not incorporate changes affecting crosswind capability; therefore, the same inherent deficiencies in the T-37B would carry over to the T-37M.

4. Landing Distance - Low Impact

UPT runways available for primary training range from 5000 to 10,000 ft. Only the primary runways were considered in the impact assessment since heavy weight landings are most likely to occur on these surfaces.

Table 2. T-37 Runways in UPT

UPT Wing	Primary Runway (ft)	Auxilliary Runway (ft)
Columbus	6300	6300
Laughlin	6236	8430
Randolph	8350	----
Reese	6500	8900
Vance	5000	8300
Williams	10000	5550

Under the original specifications (100 deg, 5000 ft PA), the NGT at T/O gross weight should be capable of landing in 5000 ft. The T-46 did not meet this 5000 ft landing requirement under the original criteria, however under ATC's revised conditions, it can land in 4885 ft. Similarly, under the original requirements the T-37M had an anticipated landing distance of 5500 ft that decreases to approximately 5180 ft under ATC's revised conditions. Vance AFB has the shortest primary runway in UPT (only 5000 ft), but its mean high PA of the highest month and its mean max temperature of the warmest month are only 1350 ft and 93 degrees. Under these conditions, the T-37M would land in less than 4500 ft, giving a margin of safety exceeding 500 ft. Considering ATC's revised conditions of 95 deg and 3800 ft PA, both the T-37M and T-46

would have a margin of safety when operating on each of the primary runways in UPT with the least room for error available at Vance AFB.

5. Ejection Capability - Low Impact

ATC has stated a requirement for an aircraft in which ejections could be safely performed under all flight conditions. Primary concern is in the low airspeed, low altitude regime where the T-37B ejection system does not safely operate. The T-37 system has been involved in 13 out-of-the-envelope ejection fatalities since the plane began operations in the 1950s.

The T-46 is capable of 0 ft - 0 kt ejections, while the T-37M would use an OA-37 type seat with a tested 0 ft - 80 kt capability and, according to the San Antonio Air Logistics Center, a probable 0 ft - 0 kt capability after further static testing. Both seats offer vast improvements over the seat currently used in the T-37B, expanding the ejection envelope in the low altitude, low airspeed flight regime.

6. Single Engine Takeoff Climb Gradient - Medium Impact

The T-37B has a limited single engine takeoff capability at high pressure altitudes and warm temperatures. In addition to changing the original NGT atmospheric conditions, ATC had to also allow for raising the gear in the revised calculations to boost the T-46 over the NGT requirement.

During testing the T-46 did not meet the 2 degree climb gradient requirement, but instead only achieved 1.4 degrees. However, under the revised conditions the T-46 attains a 2.1 degree climb gradient. The T-37M has an anticipated 0.7 degree climb gradient under the original conditions, and a projected 1.6 degree gradient under the revised conditions. Therefore, the T-37M has a projected single engine climb capability after takeoff approximately three quarters of the NGT revised requirement. This lower rate of climb reduces the margin of safety for maneuvering and clearing obstructions at low altitudes. During single engine takeoffs at high PA and temperature conditions, the T-37M would be far safer than the T-37B, but would not provide the large safety factor available with the T-46.

7. Single Engine Go-Around Climb Gradient - Medium Impact

Like the single engine takeoff climb gradient, the T-37B has performance deficiencies when executing single engine go-arounds under high PA, high temperature conditions. Under the revised NGT specifications, the T-37B is unable to sustain level flight during a single engine go-around. ATC desires a one degree single engine go-around capability without making any configuration changes under the revised conditions.

The T-46A has demonstrated a 1.1 degree climb under the revised specifications, whereas the T-37M would attain an approximate 1.0 degree climb gradient, but only after decreasing the drag by raising the gear. Similarly, raising the flaps from full to half while leaving the gear down gives a climb rate of 0.7 degrees. According to the original NGT specifications, configuration changes would complicate the emergency situation and increase the demand placed on the student pilot. If a reconfiguration allowance were made for the T-37M during single engine go-arounds, it would approach or meet the NGT requirement. Without either configuration change, the T-37M climb

gradient would be reduced to just above level flight.

8. Windscreen Capability - Low Impact

Due to the primary trainer's extensive use of lower altitudes (low level, navigation, and traffic pattern sorties) where there is increased risk of birdstrikes and possible windscreen penetrations, ATC has stated a requirement for an improved windscreen with the new trainer. Between 1975 and 1986, the Air Force recorded 1136 T-37 birdstrikes with 249 of these involving canopy/windscreen strikes. Of these, just one birdstrike involved a cockpit penetration, and this incident resulted in only \$1600 damage to the aircraft.

The T-46 windscreen is designed to withstand a 4 pound bird at 300 kts, meeting NGT specifications. The T-37M does not incorporate any new windscreen capabilities, but instead relies on the original T-37B capabilities of 4 pounds at 250 kts. With ATC's planned growth in the number of low altitude, primary training sorties, the T-37M would be more susceptible to potential damage from high speed birdstrikes; nevertheless, historical data suggests that using the T-37M windscreen instead of the T-46's would be a low impact tradeoff.

PROBLEM - AIRFRAME INSUFFICIENCY

In addition to T-37 operational deficiencies, ATC projects a T-37 fleet insufficiency and a resultant inability to meet projected AF pilot production rates beginning in FY86. This projection is based on a USAF pilot production rate of 1800 per year. ATC estimates an insufficiency of 35 aircraft by 1991, increasing to almost 70 by 1996. Since ATC assumes that the modified T-37 with its many enhancements would maintain the same utilization rate as the current T-37B trainer, these estimated insufficiencies apply to both aircraft. If the T-37Ms were able to attain a UR above 45 hours per month as discussed earlier, or if pilot production rates decreased below the 1800 level, the magnitude of this airframe insufficiency could be reduced. The T-46 is expected to eliminate the insufficiency problem due to its improved UR of 60 hours per month.

With possible termination of the T-46 program, the Air Force is considering different T-37 management actions to handle any airframe insufficiency problem and to meet pilot production needs. These hypothetical solutions are considered in the following sections, but the costs of each action, or a combination of actions, are not addressed due to the uncertainty in the magnitude of the insufficiency problem.

FACTORS BEARING ON THE AIRFRAME INSUFFICIENCY PROBLEM

1. Facts

a. Based on MAJCOM identified deficiencies in the UPT training syllabus, ATC has programmed a 20,000 hour increase in the T-37 flying program between 1987-91 (FYDP).

b. In 1985 ATC agreed to transfer 29 T-37s to TAC as O-2 replacements. SAC's Accelerated Copilot Enrichment (ACE) program will relinquish 15 of its 72 aircraft and the remaining 14 will come from the 42 T-37s flown in UNT. In return, TAC will transfer 5 T-38s to the ACE program. This exchange is

scheduled for completion in Oct 86.

c. The Specialized UPT (SUPT) program planned by ATC is designed to alleviate a projected T-38 insufficiency, but would not improve the T-37 insufficiency problem.

2. Management Actions Under Consideration By The Air Force

a. An option with uncertain political ramifications would be to reduce the UPT pilot production rate. This could entail eliminating some or all of the 100+ international students trained in the United States, subsequently decreasing T-37 demand by up to 20 aircraft per year. Similarly, reducing an equivalent number of USAF trainees would also decrease the need for additional T-37 aircraft in UPT.

b. ATC could freeze the T-37 flying hour syllabus at the FY86 level. Although eliminating the 20,000 hours added over the FYDP ignores MAJCOM identified deficiencies, it would reduce projected insufficiencies by up to 20 aircraft per year. This reduction in flying hours would have an adverse affect on the SUPT program scheduled for implementation in FY91.

c. The Air Force could reevaluate its decision to transfer 29 T-37 aircraft to TAC, or at least restrict TAC modifications to allow for their future recall to ATC. SAC's contribution of 15 aircraft involves taking a single T-37 from 15 of 17 ACE locations; and the other 14 aircraft will come from UNT with the probable elimination of the 11 sortie weapon system officer (WSO) course at Mather AFB. According to a Sep 85 HQ SAC message, the proposed drawdown of 15 T-37s would have no significant impact on ACE operations, particularly with the addition of 5 T-38 aircraft from TAC. As for elimination of WSO training at Mather AFB, increasing the formal navigator training at Holloman AFB will make up for the lost training in UNT. Therefore, the 29 T-37 aircraft scheduled for transfer to TAC could be returned instead to UPT without having a serious impact on the ACE or UNT programs.

d. The Air Force could shift some or all T-37 assets from the ACE program back to ATC, resulting in the closure of up to 16 forward operating locations (FOLs) and greater costs for SAC due to increased requirements for flying hours in major weapon systems. Even with a partial drawdown of 45 aircraft over a 3 year period, SAC projects at least 11 FOL closures. A projected T-38 insufficiency in UPT precludes ATC from replacing the T-37s with T-38s in the ACE program. However, SAC could use either an off-the-shelf aircraft or ATC's planned TTB trainer as a replacement if all T-37 assets were recalled to UPT.

e. ATC could recall some or all T-37 assets from UNT, requiring use of either an off-the-shelf aircraft or ATC's planned TTB trainer as a T-37 replacement. As with the ACE program, the T-38 cannot be used in UNT because of its projected insufficiency in UPT, not to mention its incompatibility with the UNT mission. Even with the 42 T-37s from UNT, ATC still predicts an insufficiency problem by 1992.

DISCUSSION - AIRFRAME INSUFFICIENCY

a. The intention of listing these management actions is to highlight ways of reducing any future airframe shortage; it is not intended to prioritize possible actions or be an all encompassing list of alternatives. The need for

management actions will depend on the extent of any future airframe shortage, and any improvement in the T-37M UR above ATC's 45 hours per month projection would decrease this insufficiency problem. Likewise, any reduction in the active pilot production rate below the 1800 per year level would also decrease or eliminate the projected insufficiency problem.

SUMMARY

1. The T-37M would have several performance limitations when compared to the T-46 and NGT specifications. The impact on UPT of these deficiencies is estimated in the following table.

Table 4. T-37M IMPACT ON UPT

<u>Deficiencies</u>	<u>Low</u>	<u>Medium</u>	<u>High</u>	<u>Remarks</u>
Rate of Climb		X		Slower rate reduces training per sortie
Load Factor	X			
Crosswind Limit		X		Training days lost due to crosswind increases from less than 1% to 3%
Landing Dist	X			
Ejection	X			
Single Engine Takeoff		X		Climb rate 3/4 of NGT requirement
Single Engine Go-Around		X		Gear or flap configuration change required during go-around
Windscreen Capability	X			

2. ATC's rationale for a new primary trainer is based not only on T-37 performance deficiencies, but also on a projected shortage of T-37 airframes. This airframe insufficiency problem is correctable, but the type and extent of any corrective action would depend largely on the utilization rate of a modified T-37 and on the future pilot production rate from UPT. Overall, the fully modified T-37 could fulfill the T-46 role as the next generation trainer with minor performance degradations; but the AF will need to take some management actions to alleviate the airframe insufficiency problem.

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